[Proc. Roy. Soc. Victoria, **44** (N.S.), Pt. II., 1932.]

Art. XI.—*Notes on the Faunas of the Geelong Nodule Beds.*

By R. A. KEBLE, F.G.S.

(Palaeontologist to the National Museum, Melbourne.)

[Read 8th October, 1931; issued separately 20th April, 1932.]

The following observations were made on collections of fossils made by Mr. Alan Coulson from the nodule beds of the Geelong district. An examination was made to obtain any evidence as to the conditions of sedimentation and incidentally as to age. A check list of the fossils obtained will take some considerable time to prepare, and will be published later.

Comprehensive collections were made by Mr. Coulson from nodule beds at:—

(*a*) Thompson's Creek, Moriac.
(*b*) Near the Viaduct, Batesford.
(*c*) Coghill's Hill, near Australian Cement Company's bridge.
(*d*) Curlewis.
(*e*) Lake Connewarre.
(*f*) Bowman's Well, Wellington.
(*g*) Equivalent of the nodule bed, "Learmonth," near Gheringhap.

In the previous paper[1] he has described the nodules from these several localities, and it is found that with his differentiation into (A) concretionary nodules, and (B) remanié nodules, corresponding differences in the fauna are shown. It is proposed to discuss only those critical forms that throw some light on the conditions of sedimentation and incidentally the age of the beds.

(A) Concretionary Nodules.

The concretionary nodules are bedded in the Tertiary series at Waurn Ponds and Thompson's Creek, and their age is the age of the containing beds. A comparison of Dennant and Kitson's[8] lists of Tertiary fossils from Waurn Ponds with those from Table Cape and similar faunas show that there are many forms in common. Although there are others common to the Oligocene faunas of Mornington and Muddy Creek, the Table Cape element is the critical characteristic, and the fauna of the concretionary nodule beds may be regarded as the equivalent of that of Table Cape.

(B) **Remanié Nodules.**

In the nodule material from all the localities except (*a*) and (*g*) more or less complete fragments of the crab *Ommatocarcinus corioensis* Creswell sp., are exceedingly common. This crab was described by the Rev. A. W. Cresswell[2] in 1886, and his description was subsequently amplified by Dr. T. S. Hall[4] in 1904. As stated by Hall,[4] it is very closely related to *O. macgillivrayi* White,[6] and the numerous parts from the Geelong beds show that they may be separated only with difficulty from White's species. The habits and environment of *O. macgillivrayi* may with reasonable certainty be taken as those of *O. corioensis* for there is nothing in the minute differences between them that could modify these.

O. macgillivrayi was first netted on a mud flat between tides at Port Curtis, Queensland.[6] The *Challenger*[5] also dredged in Queen Charlotte Sound, near Long Island, at the north end of the South Island of New Zealand on a muddy bottom at 10 fathoms. Hall[4] observes that the condition of many specimens at Port Campbell suggests that they must have been entombed in their burrows. He adds that other fossils in the crab beds were rare, and consisted mainly of a few spatangoids and mud haunting brachiopods.

Teeth of Cestracion were found at Curlewis and Strophodus on the Moorabool River, Lethbridge. Both these forms have a dentition adapted to the prehension and mastication of crustaceans and hard-shelled animals, and are shore fishes common to the Temperate Zone (30°–50° S.). Teeth of the Blue Pointer Shark, *Isurus hastalis*, were found at Curlewis and Bowman's Well. At all the localities except (*g*) cycloid scales were common, showing that the smaller fishes were well represented in the fauna. From Coghill's Hill, near the Australian Cement Company's Bridge, the cleithrum and median spine of a fish suggesting one of the Monocanthidae or Leather Jackets was found. Although Mr. Coulson has made comprehensive collections from all the remanié nodule beds in the Geelong district, no part of a cetacean has so far been determined. The quantity of bone fragments, however, leaves little doubt that they were fully represented.

Of the few undoubted molluscan remains, *Turritella tristira* Tate and *Crassatellites communis* have a long range through the Janjukian and Balcombian. *Astralium flindersi* is restricted to the Table Cape and Royal Park beds, and *Turris trilirata* to Fishing Point, Shelford, Mornington, and the Mitchell River. *Calliostoma* sp. occurs in the nodule bed near the Viaduct, Batesford. *Calliostoma* has several specific representatives in the beds at Table Cape but not elsewhere.

Evidence of Faunas.

There is little doubt that the bed or beds from which the remanié nodules were directly or indirectly formed comprised the equivalent of the Table Cape bed of Tasmania. The precise position of this bed in the Tertiary succession is problematical, and a comparison of its molluscan fauna with others suggests that it may be equally well placed in the Middle or Lower Janjukian. The Table Cape element is undoubtedly mixed with the fauna that existed at the time the remanié nodule beds were being formed, and the general association may be compared with that of known Lower Pliocene localities such as Beaumaris, or the upper beds at Muddy Creek.

Apart from the question of age, however, the nature and mode of preservation of the fossil forms in the remanié nodule beds leads us to other considerations that could materially influence the process of phosphatisation. Two possibilities are suggested, viz., that the remanié nodules were formed from (*a*) a Table Cape bed or beds *in situ*, in which case they would be rolled Janjukian nodules and the phosphatisation may have occurred in Janjukian times; (*b*) from an intermediate bed, in the first case derived from a Table Cape bed or beds, but also containing the remains of the fauna existing at the time of the deposition of the intermediate bed. The intermediate bed is the Lower Pliocene one referred to above, and the nodules derived from it should exhibit a mixed fauna. The later fauna contained elements such as cetaceans, fishes, crabs, &c., that could, when their remains were fossilised, account for or enrich the phosphatisation.

From their relative abundance and uniform size, their efficient sorting and homogeneity, the nodule beds are shallow water deposits, perhaps littoral. They show evidence of wave action, and were certainly deposited within the influence of wave base. Their uniformity in shape and size show that they were derived from a thin bed and rounded by abrasion.

Ommatocarcinus, by far the commonest fossil present, ranges in depth from the littoral to the uppermost limits of the benthos, and is a mud-haunting crab. Hall found his specimens in a sandy clay suggesting a muddy bottom with an admixture of sand. Where fragments are found enclosed by nodules, they show signs of abrasion, while those free from a matrix show few signs of it. It is inconceivable that unprotected fragments of such a fragile crab could escape comminution in the agitated conditions implied by the formation of the nodules and unlikely that they were subjected to the process.

If these fragments, either isolated or enclosed in the nodules, were derived from an *Ommatocarcinus* bed in the Janjukian,

such a bed would have to be in close proximity to the site of the forming nodule bed at each and every locality, a coincidence that is known not to exist.

The only reasonable inference seems to be that the fragments of *Ommatocarcinus* were preserved in an intermediate bed—a calcareous mud or sandy clay bed, which was formed in one of the valleys or depressions of the dissected Janjukian land surface afterwards drowned.[1] This bed was derived (*inter alia*) from the Janjukian sediments, and the fossil fauna found in it is a mixed one, representing in part that of the beds from which it was denuded, and in part that living at the time of its formation. Besides *Ommatocarcinus* the latter fauna comprised such sea scavengers as *Cestracion, Strophodus,* and probably many others that lived on the inshore life of the period. With such a predatory fauna, death by senile decay is unusual, and we would scarcely expect to find crabs buried simply by the accumulation of sediment. Apart from this factor the scour of the inlets, while it was to a certain extent instrumental in building sediments, was no less destructive, and the possibility of the preservation of the fragile parts of a crab with the surface layer of such a deposit was slender.

To obtain such a quantity of well preserved fragments such as we have in the collections from the nodule beds shows that *Ommatocarcinus* was abundantly preserved, and in some manner different to the ordinary methods of fossilisation. Hall's inference[4] that those specimens found by him in the sandy clays at Port Campbell were probably entombed in their burrows, appears to afford a rational explanation. In both the specimens found by him and those in the collections the appendages are frequently preserved, which shows that the crabs were not exposed to disintegrating influences and were preserved as they died. The mud between the appendages and in front of the thorax seems to bind the whole together, and appears to form the nucleus of the nodule. In the National Museum collection there are several specimens of the crab *Hemiplax,* which were found while the Yarra improvement works were in progress, suggesting the same method of preservation and the formation of nodules.

The bed from which the nodules were derived was the upper crust of this mud or silt bed that has by subsequent phosphatisation and various processes become hard and compacted. This was disintegrated and the fragments were abraded, subsequently assuming that uniformity of shape and size characteristic of the remanié nodules. Those fragments that are unenclosed by a matrix were preserved in the interstitial softer sediment.

All the fishes suggested by the remains in the nodules are shore fishes and existed through the conditions imposed by the formation of the nodule bed. On the other hand, the existence of these fish seems to be more in accord with such conditions than those implied by the Janjukian sediments.

Conclusions.

The age of the concretionary nodules is that of the containing beds, Janjukian, and the horizon approximately that of Table Cape. The evidence of the fossils of the remanié nodule beds suggests that it is a composite one, made up partly from the older Janjukian limestones, and partly from that living at the time the nodule bed was being formed.

The fragility of some of the fossils, such as *Ommatocarcinus,* shows that they could not have been transported from an older bed, nor existed during the formation of the nodule bed, without comminution. They probably came from an intermediate bed which immediately preceded the nodule bed.

The sea in which the nodule bed was formed was probably considerably under 100 feet deep in depth.

Bibliography.

1. Coulson, A. Phosphate Nodules in the Geelong District. *Proc. Roy. Soc. Vic.* (n.s.), xliv. (2), 1932.
2. Cresswell, Rev. A. W. Notes on some Fossil Crabs from the Miocene Rocks of Corio Bay. *Vic. Nat.*, iii., No. 7, p. 86.
3. Dennant, John, and Kitson, A. E. Catalogue of the Described Species . . . in the Cainozoic Fauna of Victoria. *Rec. Geol. Surv. Vic.*, i. (2).
4. Hall, T. S. A Description of *Ommotocarcinus corioensis,* Cresswell, sp., from the Lower Tertiary of Victoria. *Proc. Roy. Soc. Vic.*, xvii. (2), pp. 356-60, pl. xxiii., 1905.
5. Miers, Edward J., Report on the Brachyura. *Challenger Report,* xvii., pl. xliv., 1886.
6. White, Adam. Appendix to Voyage of H.M.S. *Rattlesnake* by John Macgillivray, 1852.